MANAGING INFRASTRUCTURE ASSETS

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CERF

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	v
1. INTRODUCTION	1
2. BACKGROUND	3
3. WORKSHOP FORMAT	7
4. WORKSHOP DISCUSSION TOPICS	9
5. WHERE DO WE GO FROM HERE?	17
APPENDIX A: LIST OF ATTENDEES	19
APPENDIX B: REMARKS BY KENNETH WYKLE, ADMINISTRATOR, FHWA	25
APPENDIX C: REMARKS BY FENTON CAREY, ASSOCIATE ADMINISTRATOR, RSPA, DOT	29
APPENDIX D: REMARKS BY MADELEINE BLOOM, DIRECTOR, ASSET MANAGEMENT OFFICE, FHWA	37
APPENDIX E: REMARKS BY CAPTAIN DENNIS PLOCKMEYER, CHIEF INFORMATION OFFICER, NAVFAC	49

EXECUTIVE SUMMARY

OVERVIEW

On May 16, 2000, the Civil Engineering Research Foundation (CERF), under the sponsorship of the National Science and Technology Committee on Technology, Research and Special Programs Administration (RSPA) of the U. S. Department of Transportation (DOT), and the Naval Facilities Engineering Command (NAVFAC), convened a forum to discuss asset management. The forum brought together knowledge and experience from industry and academia, as well as the management needs and perspectives of federal agencies with technical and management responsibilities related to very different infrastructure-asset portfolios.

This effort to revitalize and repair our nation's infrastructure using innovative materials and processes is supported by a major national initiative, the **P**artnership for the **A**dvancement of **I**nfrastructure and its **R**enewal (PAIR). In an earlier workshop focussing on the transportation component of this initiative (PAIR-T), possible *asset management strategies* were identified as key to the effective repair and renewal of the nation's infrastructure. The asset management workshop was convened in order to explore the growing experience and potential of different asset management strategies.

The workshop's objective was to help the U.S. transportation community and NAVFAC learn of asset management theory and practice from the academic and private sectors, exchange ideas of how such knowledge can be applied to publicly owned facilities, and identify research and planning actions necessary to seriously consider recommending such management methods to the organizational customers of these agencies. In this context, the "customers" are the facility users/operators who are the recipients of funds for the deployment, maintenance, and use of facility assets such as military base commanders and state transportation officials.

BACKGROUND

"Asset management" has emerged as a prominent concept in the search for economies and operating efficiencies in the public-works infrastructure community. Historically, it has generally been easier to obtain approval from legislatures for capital improvements, such as a new school or highway, than it is to get adequate maintenance budgets. As a result, owner/operators have often had to postpone all but the most critical maintenance items. One way to improve the quality of maintenance and extend infrastructure service life is to implement effective facility asset management practices.

Asset management is clearly a broad and complex subject. The public works asset manager must be concerned with establishing and maintaining an inventory of assets in the absence of explicit market transactions that might establish values and in the face of market imperfections that may distort those values, and determining whether assets are performing satisfactorily while considering the risks associated with making a decision that proves unfortunate under future conditions. Such concerns are faced at strategic levels by senior management and at the level of day-to-day operations by "hands-on" infrastructure builders and maintenance workers.

This workshop was devoted to an exploration of key topics in the area of asset management. These topics are broad and by no means constitute all the issues that must be addressed by potential users. Yet the discussion does confront some key issues. While by no means definitive, the discussion below does help establish some

common parameters that others may use when developing their own arsenal of asset management techniques and capabilities.

WHAT ARE INFRASTRUCTURE ASSETS AND HOW DO WE KNOW THEY'RE BEING PRODUCTIVELY USED?
Discussion participants commented that answering this question is made more difficult because individual agencies responsible for managing infrastructure understandably focus only on those elements of infrastructure for which they are responsible. For example, at the federal level *there is no agency that has interest in the overall system of infrastructure*. Thus the U.S. Department of Transportation will often have a very different view from those of the Department of Defense, and other units within these cabinet level agencies will each have their own perspectives as well.

Panel participants generally agreed that the various types of "infrastructure assets" have at least three common characteristics. First, they represent a substantial investment of resources, i.e., they are costly to develop. Second, they endure for a long time, i.e., they are expected to have long service lives; some participants suggested that seven years, the minimum service life considered appropriate for financing, may be an appropriate criterion. Third, they are expected to produce benefits, only some of which may have market-determined or monetary value, and entail continuing costs for operations and maintenance in addition to the initial costs of their development.

HOW CAN THE PERFORMANCE OF CURRENT INFRASTRUCTURE ASSETS BE ENHANCED?
Historically, asset management personnel and associated decision support systems have not considered the effects of cumulative actions when making current decisions. For instance, what is the cumulative effect of deicing chemicals on the condition, operation, load-carrying capacity, and remaining service life of bridge decks? Cumulative effects have not been considered, due either to a lack of understanding of the physical process or inadequate data availability. Complexity in modeling the physical phenomenon or difficulties in acquiring the necessary data are compounded by existing business processes that typically do not facilitate the consideration of such external effects on asset performance.

Workshop participants concluded that significant advancements could be made through the incorporation of advanced technologies developed through other industries, such as the defense industry, and academic research. Many of these technologies have been applied in other industries, and research could be employed to examine application within infrastructure asset management. Examples include:

- The use of parallel computing technology and dynamic simulation for asset management decision support.
- The application of sensors for the non-destructive evaluation of infrastructure components (imbedded sensors and/or remote sensing technologies).
- The use of GIS and GPS tools.
- Alternative delivery methods (design/build, design/build/operate/maintain).

WHAT ARE PUBLIC WORKS INFRASTRUCTURE ASSETS REALLY WORTH AND HOW ARE THEY VALUED FOR DECISION MAKING?
Session participants agreed that valuation of public works infrastructure assets is inherently uncertain. There is no market in which value can be directly determined through transactions between willing buyers and sellers. The estimation of value depends unavoidably on the perspectives of those who are making the estimation. However, the purpose of establishing infrastructure asset values is to support decisions about allocation of resources, and for this purpose it is possible to establish meaningful values.

Discussion participants agreed, however, that such models and their supporting information (e.g., deterioration curves) are not by themselves adequate to improve infrastructure management. The underlying concept of infrastructure asset management for some people is that the net benefits of infrastructure over the long-term are positive and infrastructure should be managed to maximize those net benefits. For others, however, infrastructure represents primarily a liability, a long-term stream of future costs that must be paid to secure certain essential services; the goal of management is to minimize these costs. *These two concepts can lead to very different management strategies.*

How do strategic issues of technology, economic structure, and public expectations influence infrastructure asset management?

It is critical to consider how we forecast and deploy new technology. Looking back at the evolution of transportation and other technologies in this country it appears that innovation works almost on a logarithmic scale. Therefore, we should expect that opportunities for deployment of new technology today will have a very short lead, say five years. *From an asset management standpoint, this means we may be looking for technology to help us with solving near term problems even though our ability to forecast specific breakthroughs is not exact at this time.* The following are some of the key strategic issues that could affect receptivity towards innovative asset management strategies.

- Narrow focus of asset management in the U.S.
- Rise of "no growth" or "smart growth" movements
- Antiquated public budgeting practices
- Fractured government responsibilities

What specific software and other tools are available to improve infrastructure asset management?

Software and tools are dependent upon effective data management systems. Workshop participants considered difficulties faced when attempting to implement new data management technologies. It frequently is difficult to change the current paradigm. Furthermore, when implementing data management techniques, such as large, multi-user relational databases or data warehouses, specialized knowledge is often required to manage and administer the systems.

The group focused on the use and purpose of the data. For example, transportation asset management, bridge, and pavement management systems are the primary decision support systems. The currently available systems provide multiple capabilities, including but not limited to the following:

- Develop optimal maintenance, repair, and rehabilitation policies.
- Identify high priority preservation and improvement projects and quantify the costs and benefits of performing these projects.
- Quantify the impact of functional deficiencies on the users of the system.
- Determine long- and short-term budget requirements for preservation, improvement, and replacement activities, and provide an assessment of the benefits of funding these activities.
- Provide performance measures for management of programs.
- Predict future conditions based on planned activities.
- Maintain data and provide search and query ability.

The data must identify unsafe conditions, quantify the deterioration of the elements, describe the functional characteristics, provide the basis for economic assessment and engineering analysis, and measure the performance of the system. Data should thus be available to describe:

- Inventory features (what is the asset, geometry, materials, etc.)
- Conditions of the elements
- Location information (spatial coordinates, descriptions, LRS, etc.)
- Hazardous situations (condition based or geometry based)
- Benefits of the asset (what mission does it support)
- Value of the asset

Where do we go from here?

It is only in the last few years that asset management approaches have been taken seriously and applied by private and public sector managers as tools for effective infrastructure management. It is no longer acceptable to look at the initial cost of construction apart from the inevitable operation and maintenance costs. Asset management approaches offer practical insights as to how best to make the tradeoffs when considering all operational alternatives.

Efforts to develop an asset management guide, an asset value study, and the convening of additional asset management workshops focusing on a peer-to-peer exchange among potential users, will provide significant direction. Asset management promises to be an opportunity to focus on the mission of organizations recognizing constrained resources, and the need for efficient operations. Most importantly, asset management recognizes that there is a diversity of facility types, and there are many different functions that have to satisfy the needs of many distinct stakeholder groups.

1 INTRODUCTION

On May 16, 2000, the Civil Engineering Research Foundation (CERF), under the sponsorship of the National Science and Technology Committee on Technology, Research, and Special Programs Administration (RSPA) of the U. S. Department of Transportation (DOT), and the Naval Facilities Engineering Command (NAVFAC), convened a forum to discuss asset management (a list of attendees is presented below as Appendix A). The forum brought together knowledge and experience from industry and academia, as well as the management needs and perspectives of federal agencies with technical and management responsibilities related to very different infrastructure-asset portfolios. The DOT has very limited direct operating responsibilities, but working in conjunction with the transportation community, oversees a large share of the nation's spending on transportation-facilities construction. NAVFAC is the Department of the Navy's technical and management agent for the planning, acquisition, and maintenance of the shore facilities infrastructure. Asset management methods appropriate for facilities recommended by NAVFAC must still be accepted by the Navy's base and operating fleet, systems, and other commanders.

If we are to maintain the quality and reliability of the nation's physical infrastructure, we must make maximum use of all the resources at our disposal, ranging from the improved performance of innovative construction materials to the most creative decision making tools. Robust asset management approaches to infrastructure renewal and maintenance are critical, under-utilized resources at this time.

Many think the broadly-defined infrastructure community is not responding to the need for asset management as quickly as other industries, primarily because the mission of those who build and maintain infrastructure is vastly different from the mission of other federal agencies. The industry is fragmented and dominated by a large number of small companies; financed in large part by limited public sector funding; characterized by its multiple levels of approval needed from local, state, and federal agencies; under pressure to perform due to increasing traffic congestion, construction delays; and, conservative and resistant to change.

This effort to revitalize and repair our nation's infrastructure using innovative materials and processes is supported by a major national initiative, the Partnership for the Advancement of Infrastructure and its Renewal (PAIR). PAIR works to overcome barriers that impede the introduction and widespread use of innovative technologies. PAIR aims to put an end to the management-by-crisis approach to infrastructure repair and renewal. PAIR works with leaders from both the private and public sectors to form collaborative partnerships that bring the very best construction technologies and processes to the marketplace. PAIR wants to shorten the unconscionably long timeframe currently needed to take "state-of-the-art" construction technologies and management strategies and deploy them on a broad scale.

PAIR is designed to supplement—not supplant—the many initiatives in both the private and public sectors that are addressing the need for proactive infrastructure repair and renewal. PAIR identifies and builds on those programs that share the same strategic mission of creatively revitalizing the infrastructure through innovative products and processes.[1]

Asset management has been identified by PAIR participants, particularly those in the transportation component of this initiative (PAIR-T), as one of the primary innovative tools that should be utilized. The National Science and Technology Council Committee on Technology, the U.S. Department of Transportation, and NAVFAC supported this workshop as a PAIR activity to start a meaningful dialogue about asset management as it relates to the objective of infrastructure renewal and maintenance. Workshop participants discussed how the use of asset management techniques could further this objective.

[1]Richard A. Belle, "The PAIR Initiative: Repairing and Revitalizing Our Nation's Physical Infrastructure," *Public Roads* (November/December 1999), 12-19.

2 BACKGROUND

The workshop's objective was to help the U.S. transportation community and NAVFAC learn of asset management theory and practice from the academic and private sectors, exchange ideas of how such knowledge can be applied to publicly owned facilities, and identify research and planning actions necessary to seriously consider recommending such management methods to the organizational customers of these agencies. The "customers" are the facility users/operators who are the recipients of funds for the deployment, maintenance, and use of facility assets such as military base commanders and state transportation officials.

The workshop's participants, DOT and state transportation agencies, NAVFAC, and other public organizations were invited to bring their management needs, knowledge, and experience. They were joined by experts and seasoned managers from both the private and public sectors who brought transferable lessons from their own experience, and who have the opportunity to shape the development of federal asset management principles and practices. Developers of tools for public sector asset management contributed their knowledge of leading-edge technology and its practical applications. Collectively the workshop was an opportunity for the transfer and furthering of asset management principles and practice for the public sector.

"Asset management" has emerged as a prominent concept in the search for economies and operating efficiencies in the public-works infrastructure community. It is generally easier to obtain approval from legislatures for capital improvements, such as a new school or highway, than it is to get adequate maintenance budgets. As a result, owner/operators have often had to postpone all but the most critical maintenance items. One way to improve the quality of maintenance and extend infrastructure service life is to implement effective facility asset management practices. Methods for condition assessment, for successful maintenance budgeting and execution, for maximum utilization, and for the out-leasing or retirement of underutilized assets must be explored, evaluated, and shared.

Asset management—the acquisition, retention, utilization and disposal of assets—encompasses several tools aimed at getting maximum utilization at minimum cost. Schools, streets, highways, bridges, right of way, airports, buildings, and utilities are all assets and as such need to be preserved to retain their value. Credible valuation of assets is complex in the absence of market-price mechanisms, as is frequently the case with public assets.

Asset management has recently achieved visibility because it may better communicate to the legislatures and other key stakeholders the need for adequate resources for facility assets. The interstate highways and other major infrastructure-development programs initiated in past decades have been substantially completed (or are in their final phases) and hence have need for programming for their upkeep. Rail systems have declined and need restoration. Housing and other built facilities require careful maintenance. Over the same period, the range of concerns influencing infrastructure decision makers has expanded to encompass environmental, equity, economic development, and other factors previously given lower priority or neglected entirely. Concurrently, new technologies have vastly increased managers' abilities to measure, collect, analyze, and extract useful information from data. Finally, explosive growth in new enterprises has expanded our understanding of what are our "assets" and enhanced awareness of asset productivity as an important criterion of managerial effectiveness. Publicity in reengineering the government has raised the public's level of expectation on the rigor and results in managing constructed facility assets. The public has a right to expect an appropriately high return on their investments in infrastructure.

New construction and major reconstruction of public infrastructure facilities have traditionally been con-

[2]Statement No. 34, Basic Financial Statements and Management's Discussion and Analysis for State and Local Governments, *Government Accounting Standards Board*, August 1999.

sidered under a capital-budgeting process distinct from the ongoing operations of government that usually pays for maintenance. Maintenance as an expense account differs from the notion of investing for the preservation of the asset's value. Many observers claim that with today's systems there is a tendency to overbuild and under-maintain facilities. The Government Accounting Standards Board (GASB) has adopted Statement 34 requiring that state and local governments include infrastructure in their financial statements and either depreciate these assets (e.g., using historical costs) or establish a condition-management system to assure that adequate maintenance expenditures are made periodically to protect the public's infrastructure investment.[2]

Theory and practice in infrastructure management have not kept pace with the recognition of infrastructure's productive potential and high cost of ownership. Many people disagree on the definition of "asset management" for public-works infrastructure. Depending on the individual's professional and organizational perspective, the phrase has different meanings. A recent American Association of State Highway and Transportation Officials (AASHTO) Peer Exchange conference on the subject defined it as "a systematic process of operating, maintaining, and upgrading transportation assets cost-effectively."[3] Consultants conducting an ongoing National Cooperative Highway Research Program (NCHRP) project to develop asset management guidance say the activity is essentially a "strategic approach to managing infrastructure."[4] A policy statement proposed for the American Public Works Association (APWA) states that "public-works asset management refers to the activities of deciding how to use society's resources to develop, operate, and maintain our infrastructure to achieve the highest possible returns."[5] In addition, the term "asset management" is widely used in real estate, finance, and other sectors of private industry to refer to investments that are more readily converted to money or other exchangeable forms of capital than are highway bridges, military dry-docks, and other public-works infrastructure.

Asset management clearly means very different things to different people. However, there is a unifying objective of efficiency. In the last few years, the transportation community, among others, has begun to understand this objective and has verbalized the subtleties of asset management. For example, Darrel Rensink, Chair of the AASHTO Asset Management Task Force, states that state DOTs have come to understand that they *already manage assets*, and what they need to do is *practice asset management*. One way to do this is to learn from other's experiences.[6]

Beyond basic definitions, objectives, and scope, asset management is clearly a broad and complex subject. The public works asset manager must be concerned with establishing and maintaining an inventory of assets in the absence of explicit market transactions that might establish values and in the face of market imperfections that may distort those values, and determining whether assets are performing satisfactorily while considering the risks associated with making a decision that proves unfortunate under future conditions. Such concerns are faced at strategic levels by senior management and at the level of day-to-day operations by "hands-on" infrastructure builders and maintenance workers.

As recently as 1995, asset management was something private sector companies did, and state DOTs and other public agencies were only beginning to think that they should be practicing. In September 1996, AASHTO and the Federal Highway Administration (FHWA) held the first asset management workshop focused on sharing experiences in both the public and private sectors. Since 1996, two more workshops have been held, and AASHTO has formed an asset management task force, which has initiated several

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[3]*Asset Management Peer Exchange: Using Past Experiences to Shape Future Practice*, Executive Summary, DRAFT, American Association of State Highway and Transportation Officials and Federal Highway Administration, Scottsdale, Arizona, December 1 - 3, 1999.

[4]Presentation by M. Markow of Cambridge Systematics, Inc., at the Annual Meeting of the Transportation Research Board, Washington, DC, January 11, 2000.

[5]Informal communication from the Leadership and Management Committee, American Public Works Association, March 2000; Larry Lux, chair.

[6]Sue McNeil, Mary Lynn Tischer, and Allan J. DeBlasio, *Asset Management: What is the Fuss?*, Volpe National Transportation Systems Center, 2000.

projects.[7] Interest in asset management has continued to grow and FHWA has formed the Office of Asset Management to provide technical support.

The FHWA Office of Asset Management develops policy and provides guidance and training related to value engineering, life cycle costs analysis and asset management consistent with the broader mission of the Administration's Infrastructure Core Business Unit to provide leadership, technical expertise, and program assistance. The office is providing assistance to the AASHTO Task Force, exploring educational initiatives, and providing support for the NCHRP project that will develop a guide for asset management.

[7]For more details on these initiatives, see the following: *Asset Management, Advancing the State of the Art Into the 21st Century Through Public-Private Dialogue*, FHWA-RD-97-046, Washington DC, September 1996; *21st Century Asset Management, Executive Summary*, Prepared by the Center for Infrastructure and Transportation Studies at Rensselaer Polytechnic Institute, Troy, New York, October, 1997; and AASHTO Asset Management Task Force, Strategic Plan 1998.

3 WORKSHOP FORMAT

After a brief overview by CERF representatives, Kenneth Wykle, FHWA Administrator, focused on the future benefits of applying asset management principles to the development and maintenance of our highway network. He spoke of the need for a comprehensive management approach to our aging infrastructure and explained how the creation of FHWA's Office of Asset Management represents a significant commitment to achieve such objectives (for full text of his speech, see **Appendix B**).

Fenton Carey, Associate Administrator for Research, Innovation, and Education, Research and Special Programs Administration, followed with a detailed analysis of some of the challenges of bringing innovation into the transportation infrastructure sector. He placed the effort to promote asset management in the context of other current infrastructure initiatives, including PAIR. Carey focused on the many barriers to accepting and implementing innovation in the management of infrastructure assets, as well as other challenges to infrastructure renewal and maintenance (for a complete set of his slides, see **Appendix C**).

Madeleine Bloom, Director of FHWA's Asset Management Office, presented a detailed overview of transportation asset management. She focused on some of the key trends driving the need for asset management, ranging from GASB Statement No. 34 to powerful technological advances. Bloom went on to explain elements of the recent FHWA reorganization, including the creation of its Office of Asset Management (for a complete set of her slides, see **Appendix D**).

A different perspective was provided by Captain Dennis Plockmeyer, Chief Information Officer, NAVFAC. He explained how the mission of NAVFAC is very different from that of DOT/FHWA or other organizations, with NAVFAC having responsibility for buildings, roads, airfields, port facilities, and other assets with a total value estimated at current replacement cost to be worth some $130 billion. The inventory of these diverse assets uses four primary classes: land, facilities, equipage, and miscellaneous property (for a complete set of his slides, see **Appendix E**).

These four formal presentations set the stage for discussions among workshop participants on how asset management techniques and technologies could be championed in their respective arenas. Workshop participants met in small groups, each structured with representatives of both the private and public sectors. A summary of these discussions follows.

4 Workshop Discussion Topics

The remainder of the workshop was devoted to an exploration of key topics in the area of asset management. These topics are broad and by no means constitute all the issues that must be addressed by potential users. Yet the discussion does confront some key issues. While by no means definitive, the discussion below does help establish some common parameters that others may use when developing their own arsenal of asset management techniques and capabilities.

What are infrastructure assets and how do we know they're being productively used?

Discussion participants commented that answering this question is made more difficult because individual agencies responsible for managing infrastructure understandably focus only on those elements of infrastructure for which they are responsible. For example, at the federal level *there is no agency that has interest in the overall system of infrastructure*. Thus the DOT will often have a very different view from those of the U.S. Department of Defense, and other units within these cabinet level agencies will each have their own perspectives as well.

Panel participants generally agreed that the various types of "infrastructure assets" have at least three common characteristics. First, they represent a substantial investment of resources, i.e., they are costly to develop. Second, they endure for a long time, i.e., they are expected to have long service lives; some participants suggested that seven years, the minimum service life considered appropriate for financing, may be an appropriate criterion. Third, they are expected to produce benefits, only some of which may have market-determined or monetary value, and entail continuing costs for operations and maintenance in addition to the initial costs of their development.

Some types of infrastructure assets may share other common characteristics as well. For example, many of these assets are held in public ownership and managed by government agencies. In many cases, the primary responsibilities for developing infrastructure assets are assigned to different institutions than ones responsible for operations and maintenance. In many cases, the benefits derived from productive use of these assets extend beyond the immediate mission they were developed to fulfill; for example, highways are expected to contribute positively to environment quality as well as to facilitate the movement of people and goods.

Because the benefits derived from infrastructure assets are so wide-ranging and because these assets are frequently in public ownership, measuring "productivity" is challenging. Public values are influential in judging productivity. Political motivations influence management decisions. Lack of management integration among interacting classes of assets, such as roads and telecommunications, obscure opportunities for enhancing asset productivity. Panel participants agreed on the whole that infrastructure asset managers lack fully effective metrics and tools for judging productivity. Progress has been made in some areas, however, such as the development of highway pavement management and bridge management tools that assist responsible officials to optimize the timing of periodic maintenance and renewal actions.

Probably the most fundamental requirement for effective infrastructure asset management is the data comprising a meaningful inventory of those assets, including their condition. Advances in information technology are making available increasingly sophisticated tools for database development, and infrastructure managers are gradually applying these tools. The complexity and high cost of acquiring inventory data (including information on infrastructure condition) for existing infrastructures are factors retarding penetration of these tools into current management practices.

How can the performance of current infrastructure assets be enhanced?

Historically, asset management personnel and associated decision support systems have not considered the effects of cumulative actions when making current decisions. For instance, what is the cumulative effect

of de-icing chemicals on the condition, operation, load-carrying capacity, and remaining service life of bridge decks? Cumulative effects have not been considered either due to a lack of understanding of the physical process or inadequate data availability. Complexity in modeling the physical phenomenon or difficulties in acquiring the necessary data are compounded by existing business processes that typically do not facilitate the consideration of such external effects on asset performance.

The infrastructure design and construction community has a tendency to take an incremental approach towards enhancing the system. This is the partially the result of prescriptive design codes and construction specifications which limit the implementation of new technologies. The incremental approach in design and construction translates to the practice of asset management through the resulting culture and the constraints placed upon decision-makers. Performance-based design codes may facilitate the utilization of new technologies to enhance both the system and the system components. Incentives should be provided for superior quality and enhanced performance.

It was recognized during workshop discussion that infrastructure owners have a tendency to focus on short-term issues. This "focus on today" pervades all aspects of asset management decision making. Nearly all outsourced construction activity is let using a low-bid approach based on the first cost. Life cycle cost approaches are seldom utilized.

There is a significant resistance to change in public infrastructure-owning agencies. Parties responsible for design, maintenance, and construction tend to follow past practice. When new technology becomes available, owning agencies tend to delay implementation until the technology is proven through implementation by another owning agency (i.e. no one wants to be first). This inertia results from lack of incentives, the short-term business process, and litigation, each of which contribute towards the lack of innovation.

Workshop participants concluded that significant advancements could be made through the incorporation of advanced technologies developed through other industries, such as the defense industry, and academic research. Many of these technologies have been applied in other industries, and research could be employed to examine application within infrastructure asset management. Examples include:

- The use of parallel computing technology and dynamic simulation for asset management decision support.
- The application of sensors for the non-destructive evaluation of infrastructure components (imbedded sensors and/or remote sensing technologies). Such technologies provide more quantitative information and, with technology advancements, there are a wide variety of approaches that may become viable for widespread data collection. Such approaches may produce either real-time or post-processed information.
- The use of GIS and GPS tools.
- Alternative delivery methods (design/build, design/build/operate/maintain).

A significant amount of *additional research* is required to advance the state of the art and enhance the performance of the system, including:

- Research to obtain a greater understanding of the long-term effects of external variables on physical asset deterioration (e.g., how do we model the effects of de-icing on long-term bridge deck conditions for system-level and project-level modeling).
- Isolation of parameters and decision algorithms to permit consideration of such effects (long-term effects due to external influences such as de-icing) within the asset management process.
- Investigation of the feasibility of utilizing new, state-of the art technologies, such as parallel processing and dynamic simulation, to more effectively model the system. Quantify the benefits of utilizing new materials, data-warehousing techniques and spatial analysis tools, and alternative delivery methods.
- Development and deployment of enhanced sensor technologies for project-level and system-level asset management.
- Research of alternatives for enhanced integrated asset management systems which provide decision support for multiple, interdependent features simultaneously (i.e., integrated decision support for bridges, pavements, hardware, etc.).
- Research to determine if alternative, novel policies, such as demand management (e.g., time shift-

ing, congestion pricing, regulatory mechanisms), are effective alternatives for facility construction, reconstruction or improvement.

- Quantification of the roles of risk reduction and reliability improvements, downtime reductions, and maintainability and maintenance strategies in delivering high performance for the system.
- Examination of applications of new information technologies for operations and control, and for integrated asset management decision support.
- Investigation of the interrelation between asset management and operations management, asset value and socioeconomic factors, and asset condition on user costs.

These new technologies will not be implemented easily. A number of changes in business assumptions and political behavior will be necessary for these innovative technologies to be embraced and utilized. Specifically, workshop participants believed that negotiations will need to:

- **Exert political will.** While discussing the current working assumptions and standards, there were many instances where the business process hindered the introduction and/or application of new technologies. The use of new technologies and new approaches are essential for enhancement of the system. As infrastructure elements are owned predominantly by public agencies, there must be political will to drive changes in the current practice. Federal agencies may be required to "force" change by requiring integrated decision support and the consideration of long-term issues.
- **Synergize multiple efforts through partnerships.** There are frequently multiple, synergistic efforts that are undertaken within public agencies. For instance, an agency may focus on quality initiatives, strategic partnerships and integrated asset management approaches. There are avenues for such programs to focus on complementary issues. Such avenues should be pursued.
- **Change business practices.** Frequently, decision making processes for one asset class are separated from decision making processes for complementary asset classes (i.e., pavement management decision are made separately from bridge management and safety management decision making. Asset management personnel for these classes frequently do not interact with maintenance personnel). Re-engineering of business processes is required to facilitate integrated asset management decision support, synthesis of data, etc.
- **Identify critical information and undertake efforts to collect the required data.** The success of such efforts are contingent upon political will and changes in business practices.
- **Provide incentives to all stakeholders.** Benefit can be obtained by altering the business process so that all stakeholders (owners, contractors, engineers) have greater incentives to provide elements which enhance the performance of the system.
- **Utilize risk-management tools.** Risk management tools should be incorporated to consider natural hazards and extreme event retrofit within the decision support systems in a quantitative fashion. Quantitative tools can also be incorporated considering the risk of increases in life cycle and first costs. Policy and legislative actions should also be taken to minimize litigation risks.
- **Overcome fear of failure in the public sector.** Through discussions, it became evident that there is a tendency to maintain the status quo within the system. It appears that owners prefer for other parties to implement and prove new technologies before they consider application within their inventory. This tendency is partially the result of a fear of failure. Managerial strategies should be employed to encourage innovation and overcome this fear of failure.
- **Quantify costs of not enhancing the performance of the system.** Decisions are routinely made using first costs to prioritize competing activities in an environment of limited available funds. Rarely are the costs of not enhancing the system included within this process. The impacts of decisions must be quantified and included within the decision support algorithms.

What are public works infrastructure assets really worth and how are they valued for decision making?

Session participants agreed that valuation of public works infrastructure assets is inherently uncertain, a matter of estimation. There is no market in which value can be directly determined through transactions between willing buyers and sellers. The estimation of value depends unavoidably on the perspectives of those who are making the estimation. However, the purpose of establishing infrastructure asset values is to

support decisions about allocations of resources, and for this purpose it is possible to establish meaningful values.

"Resource allocation" refers to such decisions as establishing an appropriate balance between initial costs of infrastructure construction and recurring costs for operations and maintenance, or among investments in various components of infrastructure. Infrastructure professionals need a reliable means for resolving differences among engineering, financial, and political perspectives that enter into resource-allocation decision-making.

Recent trends in infrastructure management practice have accentuated this need. Experience with pavement- and bridge-management tools has demonstrated that such tools can indeed help agencies to improve infrastructure performance, and it has become possible to manage infrastructure assets to meet explicitly stated performance goals. Efforts to comply with GASB Statement 34 are focusing attention on issues of asset valuation and performance management. A key impediment to progress is the lack of adequate data for development of reliable estimates of future infrastructure performance likely to result as a consequence of management decisions.

Many agencies' efforts to comply with GASB Statement 34 include making comprehensive appraisals of current replacement costs for their asset inventories. These estimates rely on a combination of standard engineering cost estimating techniques and comparisons with comparable facilities. NAVFAC, for example, has made such an estimate using in-house staff resources and consultant services to test and verify staff estimates. (Federal agencies are not subject to GASB standards, but Department of Defense agencies have a congressional mandate to develop financial statements similar to those in the private sector.) The New York State DOT has taken a similar approach, using deterioration curves and deflation factors to convert current replacement costs into estimates of acquisition or base costs to be used in depreciation calculations.

Some discussion participants questioned the value of GASB Statement 34 as a basis for improving decision making, asserting that standard approaches to cost estimation and depreciation are unlikely to yield meaningful information. Others argued that the exercise of putting infrastructure assets on the government's balance sheet and explicitly tying infrastructure on the balance sheet to the income statement with depreciation cost estimates is an important first step toward better management practice; in the future, technically based estimates of depreciation may provide the needed bridge between engineering and financial perspectives on infrastructure management.

Some participants argued that the absolute value of infrastructure assets is less important than the relative changes in value from one period a to the next as a result of usage and aging. Estimating changes based on presumed management strategy provides the information needed for resource allocation decisions.

Panel participants agreed that much work is needed to develop deterioration curves responsive to management strategies for a wide range of infrastructure asset types. Work is needed also to develop management tools of the types now being used for highway pavements and bridges and airfield pavements for other types of infrastructure.

Discussion participants agreed, however, that such models and their supporting information (e.g., deterioration curves) are not by themselves adequate to improve infrastructure management. The underlying concept of infrastructure asset management for some people is that the net benefits of infrastructure over the long-term are positive and infrastructure should be managed to maximize those net benefits. For others, however, infrastructure represents primarily a liability, a long-term stream of future costs that must be paid to secure certain essential services; the goal of management is to minimize these costs. *These two concepts can lead to very different management strategies.*

How do strategic issues of technology, economic structure, and public expectations influence infrastructure asset management?

Much of this discussion centered on Intelligent Transportation Systems (ITS) and the automated roadway as an example of how to integrate new technology into the highway system. ITS is looked to as a means of developing more capacity on our existing facilities

and the automated roadway, when deployed, could measurably increase capacity. The technology, while feasible, must be worked out practically, with cost always a consideration. As deployment starts, however, we see productivity increasing (capacity) with a marked drop in cost to deploy.

This leads to the issue of how to forecast and deploy new technology. Looking back at the evolution of transportation and other technologies in this country, it appears that innovation works almost on a logarithmic scale. Therefore, we should expect opportunities for deployment of new technology today on a very short lead, say five years. *From an asset management standpoint, this means we may be looking for technology to help us with solving near term problems even though our ability to forecast specific breakthroughs is not exact at this time.* The following are some of the key strategic issues that could affect receptivity towards innovative asset management strategies.

- **Narrow focus of asset management in the U.S.** The general feeling among participants was that our current asset management is based too much on incremental thinking, rather than on exponential thinking and action. At present not enough leaders appear willing to take broad steps forward in embracing asset management to really make tremendous gains in improving our facilities and the cost picture for service.
- **Rise of "no growth" or "smart growth" movements.** A major factor affecting asset management is to reconcile the no growth or "smart growth" strategies that are advocated politically by some groups tothe management of transportation facilities. Much of the infrastructure through older areas is in need of upgrading, modernization, etc. Improved capacity for many reasons is always a consideration when renewing infrastructure, but that is seen encouraging growth. The dilemma then is to reconcile service, safety, and loss of business in asset management if a "no growth" policy is decided upon. Simply rebuilding an old facility in its original form is not the answer. This issue needs much discussion to identify all the possible approaches.
- **Antiquated public budgeting** (line item budgets, "use it or lose it" practices, backward looking planning and budgeting vs. forward looking). Many agencies have budgeting processes based on the way business was conducted at the turn of the last century (1900), or even before that. Too often budgets are based on what we did in the past, not on what we want to achieve. Many budget oversight agencies seem reluctant to relinquish even day-to-day control over funds to the responsible agency. This breeds inefficiencies through delays and disagreements on specific details. Asset management offers an opportunity for both transportation agencies and budget oversight agencies to agree on specific goals of what budgeted funds are to be used to accomplish. The achievement of those goals can be tracked based on reporting of performance measures to track the progress against an agreed upon schedule. With the basic computer tools available for the reporting, measuring, etc. can be easily worked out for such a process. An important exercise for both agencies, however, is to evaluate "what if" scenarios on how best to program improvements based on goals at the start of the actual budget process. To maximize the efficiency of this process, economic models or other predictive processes need to be developed. Currently there are few models available to cover the wide range of activities and their inter-relationships that need to be evaluated.
- **Fractured government responsibilities** (state, local, federal; transportation planning vs. land use planning). Under this issue, it is necessary to focus on the evolution of the planning process, participa-tory planning, and the problem of jurisdictional boundaries vs. regional needs. While there have been a few good examples of regional-level governments that have allowed truly regional systems to develop, too often these efforts fail. Many of the reasons for failure are simply that no group wants disruption from a transportation project, even if the project will ultimately benefit the area. Often the environment is an issue that can be resolved, but only through a solution that proves unacceptable to one group or another. Much of the problem of trying to operate on a regional scale is the result of the myriad needs of the various political jurisdictions, with no common goal among all their diverse interests to unite them around the work that must be done to meet the project's challenges.

Several elements will help facilitate implementation of asset management. The challenge, however, is particularly great for the public sector, given the transient nature of political leadership and the lack of support for "succession planning." Defining the vision and the requisite support for implementation are per-

haps the key strategic efforts needed to make asset management a reality in our organizations.

- **Predictive research**. Research is ongoing, but what is needed is a departure from the traditional research focus. One of the problems of our current management of infrastructure is that each element, e.g., pavement, bridges, guide rail, etc., are managed in a vertical structure. It is imperative to develop a horizontal integration of management decision making. To facilitate this, predictive models to evaluate "what if" scenarios need to be developed as one facet of a research effort.
- **Future orientation**. Currently most of our infrastructure management is geared to short- range objectives, usually five years. This is hardly long enough to really achieve benefits from many newly developed materials on operating strategies. The planning process of the 1960s and 1970s looked at a horizon of 20 to 25 years for regional forecasts. Granted, these forecasts were general, but they created an excellent basis for judging needs and alternative ways of meeting those needs. Asset management would greatly benefit if its options could be judged against a horizon of 10 to 15 years when choosing options involving life cycles of 12 to 15 years for pavement, 35 to 50 years for bridges, etc.
- **Clarity of vision**. One of the most important aspects of transportation infrastructure asset management is understanding what type and size of vehicles will utilize facilities in the future. It is imperative that a dialogue be initiated between the facility owners and operators and the vehicle manufacturers. For example, capacity increases though ITS that are made possible by radical changes in vehicle technology such as guides roadways made possible by on-board vehicle control systems; another might be an electric powered roadway where vehicles pick up energy and guidance from an in-pavement power system. These examples are more than just ideas, for prototypes now exist and planning should begin immediately in a broad overview of how to utilize this and other promising technology in managing infrastructure.
- **Convergence**. Over the last four decades we have seen an acceleration of technology in response to challenges. The interstate highway system was begun with only basic tools and technology. Yet by the time a decade had passed the equipment available to complete it was much more efficient and productive. The same can be true of managing our assets. When a true shift is made from emphasis on building to managing and upgrading, the industry will respond. Creating the environment for asset management will bring the economic change to exploit it well.

What specific software and other tools are available to improve infrastructure asset management?

Software and tools are dependent upon effective data management systems. Workshop participants considered difficulties faced when attempting to implement new data management technologies. It is frequently difficult to change the current paradigm. Furthermore, when implementing data management techniques, such as large, multi-user relational databases or data warehouses, specialized knowledge is often required to manage and administer the systems.

Implementation difficulties become compounded when attempting to integrate data across various divisions of an agency. For instance, in a typical state DOT structure, bridge maintenance and construction are performed separately from pavement maintenance and construction. These and other interrelated business functions are organizationally succinct and there is little interaction between employees within these departments. Cases could be envisioned where these organizational units employ specialized, and perhaps even stand-alone, data management systems that are incompatible with the systems employed by other divisions of the agency. This familiar 'silo' effect, both from a data standpoint and a business process standpoint, impedes efforts for data-integration throughout an agency.

The development of enterprise data solutions frequently requires the collection of additional information. Group participants articulated resistance by employees to collect additional information. This resistance is typical throughout private and public agencies. Frequently, arguments against collection of additional information are based upon data collection costs. There are many cases where the costs of collecting the current information are unnecessarily high as a result of not implementing new technologies. For instance, many agencies rely upon mainframes for data maintenance. The data models utilized by such systems require users to repetitively enter static information, which increases data collection and processing costs. Modernization

of the data models and data management systems could eliminate repetitive data and thus reduce the collection costs.

The group focused on the use and purpose of the data. For example, for transportation asset management, bridge and pavement management systems are the primary decision support systems. The currently available systems provide multiple capabilities, including but not limited to the following:

- Develop optimal maintenance, repair, and rehabilitation policies
- Identify high priority preservation and improvement projects and quantify the costs and benefits of performing these projects
- Quantify the impact of functional deficiencies on the users of the system
- Determine long- and short-term budget requirements for preservation, improvement, and replacement activities, and provide an assessment of the benefits of funding these activities
- Provide performance measures for management of programs
- Predict future conditions based on planned activities
- Maintain data and provide search and query ability

The data must identify unsafe conditions, quantify the deterioration of the elements, describe the functional characteristics, provide the basis for economic assessment and engineering analysis, and measure the performance of the system. This decision support must accommodate the concerns of all parties involved in management of the asset, from long-term, strategic planning to project implementation. Data should thus be available to describe:

- Inventory features (what is the asset, geometry, materials, etc.)
- Conditions of the elements
- Location information (spatial coordinates, descriptions, LRS, etc.)
- Hazardous situations (condition based or geometry based)
- Benefits of the asset (what mission does it support)
- Value of the asset

Based on this data, the decision support system evaluates action options, displays useful information, and assesses risk while being flexible enough to share data with other applications.

The current state of the art for data management includes a wide variety of data-modeling techniques, including relational database management systems, object-oriented databases, data-warehousing, and spatial databases. These systems have been successfully implemented in numerous other businesses and are currently being examined or implemented by public agencies. Though it is not a trivial task to implement these systems, the technology has been proven and, with effort and dedication, enterprise-wide data systems can be implemented.

Information technology is not only limited to the data-management system. Real time data may be collected and used for decision support. Detailed, quantitative information can be collected on the assets. Frequently, the collection of such information is facilitated by the use of new computer technologies, such as wearable computers and digital imagery. Such state-of-the-art technologies are used sparingly in the public sector but are commonplace in other industries.

Remote sensing technologies have been developed for military applications and within other industries. Many of these technologies can be employed for infrastructure management purposes. For instance, GPS technology could be employed to locate features within the system. Non-contact sensors may be utilized to rapidly collect quantitative condition information. Embedded sensors have been developed which could be employed to give detailed information for future management.

Advanced decision support techniques have been developed through research efforts or through prototype development. For instance, preservation and improvement decision can be supported with optimization procedures. Currently, management systems have been developed to provide such decision support capability; however, these systems are currently used sparingly by public agencies, which typically rely on basic prioritization procedures. The optimization procedures developed within these systems can be enhanced using more sophisticated techniques (for instance, with bridge and pavement management optimization pro-

cedures could be enhanced to permit consideration of alternative constraints). Artificial intelligence techniques can be utilized to enhance predictions and resource allocation procedures. Spatial interdependencies can be modeled through existing GIS system. Life cycle cost analysis procedures have been developed and could be implemented for decision support.

To advance asset management, *additional research* is required to determine appropriate ways to restructure the data-models and data collection process and develop enhanced decision support algorithms based on more detailed, quantitative information. IT advancements should be investigated to collect and utilize more detailed, quantitative information with less effort. Areas of future research include the following:

- Benefits of alternative data-modeling procedures (data-warehousing, relational structures, object-oriented structures).
- Decisions that an asset management system is required to support throughout the business process and evaluate the data required to support these processes. The data requirements can then be compared to the existing information and the business process can be re-engineered to accommodate a new system.
- More appropriate performance measures.
- Impact of work within one asset class (bridges, pavements, or hardware) on the rest of the system. Research is required to develop appropriate decision support algorithms for this type of integrated asset management decision support.
- Better decision support systems. Such information must be collected with less effort. For instance, bridge element conditions are subjectively assessed using visual inspection. Sensors can be developed and employed to quantitatively assess deck conditions in a non-contact fashion. Research should be undertaken to develop such technologies.
- Applications of rapidly evolving IT technologies, such as Internet and remote sensing applications.

[8]Madeleine S. Bloom, "Report on Government Accounting Board's Infrastructure Proposals to AASHTO Asset Management Task Force," Little Rock, Arkansas, April 1999.

5 *Where Do We Go From Here?*

It is only in the last few years that asset management approaches have been taken seriously and applied by private and public sector managers as tools for effective infrastructure management. It is no longer acceptable to look at the initial cost of construction apart from the inevitable operation and maintenance costs. Asset management approaches offer practical insights as to how best to make the tradeoffs when considering all operational alternatives.

There are significant political implications to the use of effective asset management. In the words of Madeline Bloom,

> Infrastructure is so significant, it should not be omitted from state and local government balance sheets...Adding highway infrastructure to the balance sheets of states will heighten the importance of these assets and draw attention to the need to maintain their condition, which is positive. It must be clearly understood, however, that as important as maintenance is, infrastructure investment by States must necessarily look at issues beyond condition in order to capture performance and economic productivity goals. Performance in terms of level of service (congestion) will be reflected in improvements such as new lanes, and ITS treatments, that would not be captured in condition costs. Economic cost will look beyond condition in the sense it will factor in level of travel, time cost to the user and related user costs. These will vary among facilities and networks.[18]

Efforts to develop an asset management guide, an asset value study, and the convening of additional asset management workshops focusing on a peer-to-peer exchange among potential users will provide significant direction. Asset management promises to be an opportunity to focus on the mission of organizations recognizing constrained resources and the need for efficient operations. Most importantly, asset management recognizes that there is a diversity of facility types, and there are many different functions that have to satisfy the needs of many distinct stakeholder groups.

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APPENDIX B: OPENING REMARKS

KENNETH R. WYKLE, FHWA ADMINISTRATOR

Good morning! I'm going to be focusing on the future benefits of applying asset management principles to our highway network. To get started, I'd like to look at where we've been.

We've come a long way in 100 years. A hundred years ago, FHWA consisted of two people operating out of an attic with a budget of $10,000. In the U.S. and around the world, railroads dominated the early part of the 20th century. Cars and trucks came to the forefront by the 1950s. The U.S. responded by constructing our Interstate System . . . it knit this nation together.

CURRENT SITUTATION

Today, FHWA has about 3,000 federal employees, with many thousands more at state DOTs and local government road agencies.

Our budget is nearly $30 billion—counting all the funds spent by states, cities, counties, and other organizations, total annual highway expenditures exceeds $120 billion. Our achievements are a big part of what America is today.

- The construction of the Interstate was recently recognized by the American Society of Civil Engineers as one of the top 10 engineering achievements for the past millennium.
- All of us contributed to this achievement.

Today, the Interstate System is basically complete.

- We will continue to maintain it, improve it, and add a few miles.
- What we will not be doing is adding thousands of new miles.

The task ahead—our future challenge—is two-fold.

- First, get the most capability from our existing capacity by applying technology to transportation. In other words, operate the system for peak efficiency.
- Second, protect our trillion dollar investment in infrastructure by maintaining and renewing what we have. In broad terms, that means asset management.

IMPORTANCE OF ASSET MANAGEMENT

Transportation asset management can be defined as a systematic process of maintaining, upgrading, and operating assets cost-effectively.

- It combines engineering principles with sound business practices.
- It provides tools to facilitate an organized approach to decision making from an economic and a customer perspective.

Asset management is key to maintaining our infrastructure. It's important because much of our future infrastructure is what you see today.

- The bridges that we are constructing today, the roads we are constructing and repairing . . . we are going to be using them 20 years from now.
- Our challenge is to preserve and manage cost-effectively what is here today. In fact, in the U.S., and throughout the developed countries of the world, there has been a shift from constructing new highway systems to preserving, maintaining, and operating what we have.

Implementing Asset Management

Transportation agencies worldwide are implementing or investigating asset management systems.

- There is a need for a comprehensive management approach given the common background of aging infrastructure, less than fully adequate budgets, constrained staff resources and, at the same time,
- Increased expectations for transportation from the public.

Managing highway assets is not a new concept.

- State highway agencies have been developing and utilizing pavement, bridge, and maintenance management systems for at least the past two decades.
- Up to now, asset systems have to a large degree been viewed separately.
- Pavement engineers have been responsible for pavement.
- Bridge engineers for bridges.
- And each group has worked with its own set of data.

What makes asset management a unique concept today is the move to merge these single-asset management systems into a unified approach. Asset management emphasizes the entire system and incorporates a multi-year perspective.

Asset Management at FHWA

The creation of our Office of Asset Management at FHWA represents the shift in focus. Working with AASHTO, we have made it clear that the full potential of asset management is reached only when systems are managed together. Systems integration is a major goal of the office.

- We cannot meet the needs of the new century using generations-old products and strategies to repair and renew critical physical facilities.
- A piecemeal approach will only allow us to move from crisis to crisis.

In evaluating a broad range of resources and assets over a fairly long time frame, asset management can result in different decisions than if each action were evaluated alone.

Some projects make more sense when you look at the big picture . . . the longer time frame.

- Developing materials that will allow us to build 100-year bridges. (Why should our children rebuild the same bridge we spent so much effort to construct?)
- Research that is leading to smoother, longer-lasting pavement.

From an agency perspective, asset management will result in improved management of programs and more cost-effective use of available funding. From a user perspective, the customer will benefit by receiving better managed facilities and more efficient operation of the transportation system.

As we spread the word on the importance of asset management, we have to take care with how we communicate.

- Use plain language, not jargon.
- Highway users have to understand what we are trying to do.

Cooperative Efforts

States, acting through the American Association of State Highway and Transportation Officials (AASHTO) and in cooperation with FHWA, have made transportation asset management a national priority.

- During the 1990's, AASHTO and FHWA jointly sponsored a series of workshops to benchmark the application of asset management in transportation agencies.
- AASHTO is providing national leadership and guidance as States work to incorporate asset management principles and practices into their business process.

As part of the reorganization efforts at FHWA, we created an Office of Asset Management in February of 1999.

- The Office is providing technical assistance by developing tools, techniques, training and consultative services for States as they work to adopt comprehensive asset management programs.
- We are making performance and return-on-investment considerations an integral part of program evaluation and project selection.

Madeleine Bloom, the first Director of the office, is here today and will share more detailed perspectives with you later this morning.

Conclusion

Our enormous highway investment reflects a sustained public commitment over many decades. Our network provides us with reliability and outstanding service, almost all of the time. The system helps to sustain economic growth, maintains personal mobility, and ensures our national security.

Sustaining this performance is a challenge to everyone in transportation. With leadership from the Office of Asset Management, FHWA intends to be part of the solution. We will work—with all of you—to manage transportation assets. The American people will benefit greatly from our achievements. This workshop B your work today B can help show the way.

APPENDIX C

FENTON CAREY, ASSOCIATE ADMINISTRATOR, RSPA, DOT

Bringing Innovation to the Transportation Infrastructure Sector

Managing Infrastructure Assets Workshop

May 16, 2000

Transportation Assets

- 160,000 miles of interstate and national highway system roads
- 3.8 million miles of other roads
- 5,352 public use airports
- 200,000 miles of regional and local freight railroads
- 24,500 miles of Amtrak
- 26,000 miles of navigable water ways
- 200,000 miles of oil pipelines
- 1.2 million miles of gas lines

Transportation Vehicles

• Passenger cars	130 million
• Trucks	7 million
• Buses	700 thousand
• Freight cars	1.3 million
• Vessels	41 thousand
• Locomotives	20 thousand
• Transit and commuter rails	15 thousand
• Ships (>1,000 tons)	500

National Transportation System

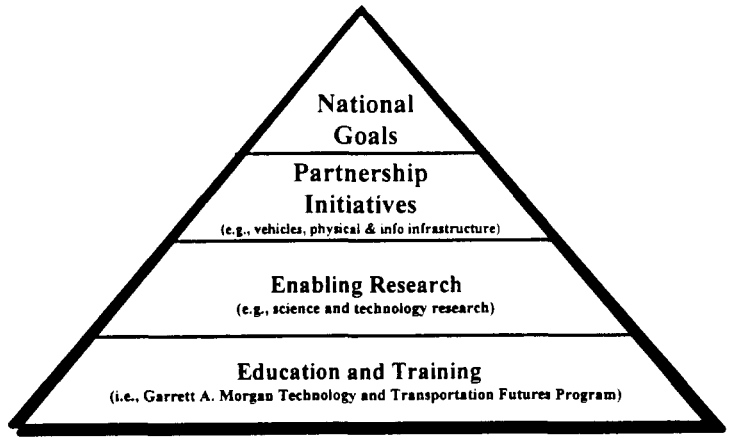
- **Challenges**
  - Human Cost (e.g., Fatalities, Injuries)
  - Congestion
  - Aging Population
  - Expanding Trade and Tourism
  - Environmental Concerns
  - Terrorist Threats
  - Advancing Technology
  - Massive Infrastructure
- **Opportunities**
  - Reduce Transportation-related Deaths, Injuries and Property Loss
  - Provide Access and Mobility for all Americans
  - Reduce Travel and Construction Time and Cost
  - Increase Throughput of People and Freight
  - Reduce Environmental Impact
  - Enhance System Security

Strategic Planning Process

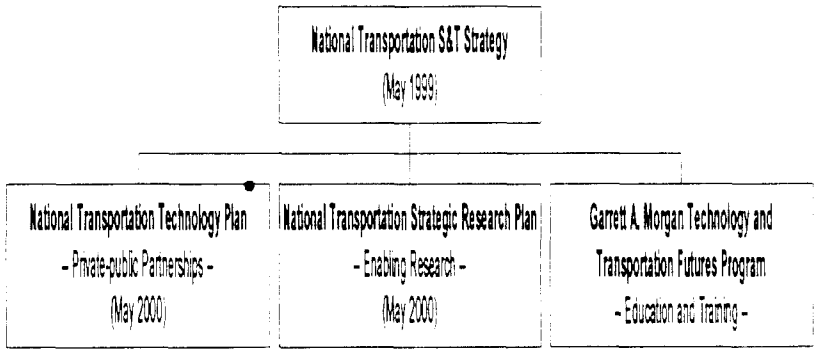
- **Strategy**
  - Presidential Directives, OSTP/OMB Annual Budget Guidance, etc.
  - *NSTC Transportation S&T Strategy*
- **Planning, Programming and Budgeting**
  - Department Strategic and Performance Plans
  - *NSTC Transportation Technology and Strategic Research Plans*
- **Implementation**
- **Evaluation**
  - Quality/Self Assessments (e.g., Malcolm Baldrige, ISO 9000)
  - Program/Project Reviews
  - Technology/System Assessments
  - Peer/Independent/Expert Reviews (e.g., NRC, TRB)

Strategic Planning Approach

(*NSTC National Transportation S&T Strategy*, May 1999)



National Transportation S&T Strategy and Implementation



Public-Private Partnerships Initiatives

- Accessibility for Aging and Disadvantaged Populations
- Aviation Safety Research Alliance
- Enhanced Freight Movement at Gateways
- Enhanced Transportation Weather Services
- Intelligent Vehicle Initiative*
- Maritime Safety Research Alliance**
- **Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure (Partnership for the Advancement of Infrastructure and its Renewal - Transportation)**
- National Intelligent Transportation Infrastructure
- Next-Generation Global Air Transportation
- Next-Generation Transportation Vehicles*
- Space Transportation Technologies**
- Transportation and Sustainable Communities*
- Transportation Infrastructure Assurance*

* New Titles ** New Partnerships

Partnership for the Advancement of Infrastructure and Its Renewal (PAIR-T)

- **Goals:**
  - Accelerate the comprehensive renewal and advancement of the Nation's transportation infrastructure using stronger, cheaper and environmentally superior materials and more cost-effective delivery systems
  - Reduce waste, pollution, and emissions generated in the production of infrastructure materials.
- **Objectives:**
  - Create an environment that fosters an unprecedented level of collaboration and synergy on infrastructure research, demonstration, testing and evaluation and technology transfer to State and local agencies.
  - Develop new technologies, concepts and ideas and and accelerate market acceptance of existing and new products, processes and services.

PAIR-T Participants

- **Commerce**
- **DOT** (e.g., RSPA, FHWA)
- **DoD**
- **NSF**
- **Industry** (e.g., CERF, CIRT, ARTBA)
- **Academia** (e.g., UTCs)
- **State and Local Government Organizations** (e.g., AASHTO, National Governors Association)
- **Others** (e.g., TRB, Council on Competitiveness, NAE)

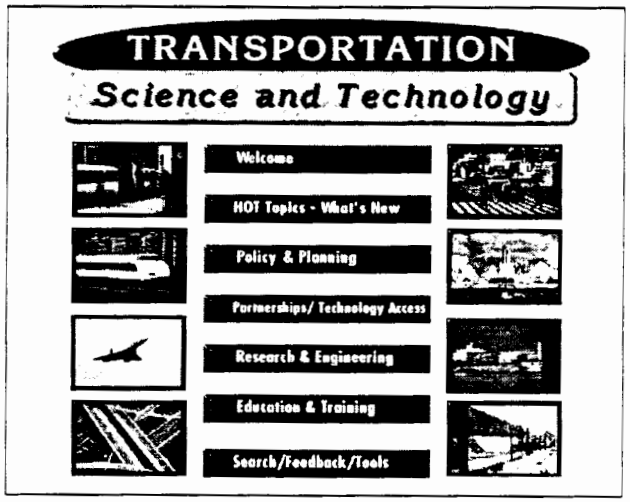
PAIR-T Schedule

• April 7, 1998	NSTC PAIR-T Workshop
• June 30, 1998	NSTC PAIR Workshop
• July 7-8, 1998	NRC/TRB Committee review
• April 26, 1999	NSTC PAIR-T Roadmapping Meeting
• June 14-15, 1999	NRC/TRB Committee review
• September 1999	NSTC Procurement Reform Workshop
• October 1999	CERF/CIRT Validation Workshop on PAIR
• **May 2000**	**NSTC Workshop on Asset Management**
• August 2000	CERF International Trade Show and "Symposium 2000: Moving Innovation into Practice for a Sustainable Future"

Requirement for Asset Management?

- Comprehensive, accurate, timely and cost-effective management of assets:
  - Inventory
  - Condition
  - Performance
  - Trends

http://scitech.dot.gov



APPENDIX D

MADELEINE BOOM, DIRECTOR, ASSET MANAGEMENT OFFICE, FHWA

Transportation Asset Management

Civil Engineering Research Foundation
May 16, 2000

Presented by: Madeleine Bloom, Director
Office of Asset Management, FHWA

Agenda

- Introduction
- What is Asset Management?
- Why Asset Management?
- How do we get there?
- Conclusion

What is Asset Management ?
Working Definition

- No "definitive" definition
- Bottom-line: Cost-effective resource allocation and programming decisions

FEDERAL HIGHWAY ADMINISTRATION

Asset Management

What is Asset Management ?
Working Definition

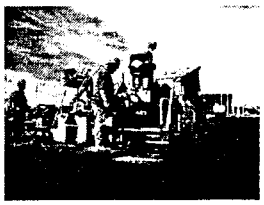
- No "definitive" definition
- Bottom-line: Cost-effective resource allocation and programming decisions

FEDERAL HIGHWAY ADMINISTRATION

Asset Management

What is Asset Management ?

What it means....



- Partnership
- Consensus
- Information based
- Strategic Resource Allocation
- Performance Measurement
- Feedback

What is Asset Management ?

What it means....

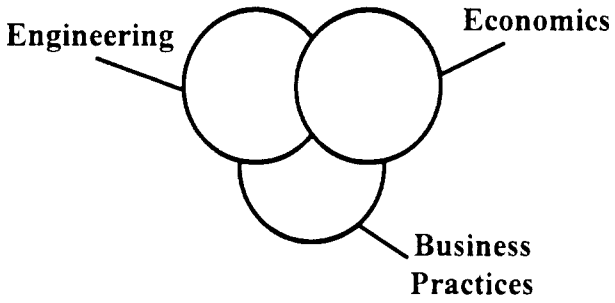
- Partnership
- Consensus
- Information based
- Strategic Resource Allocation
- Performance Measurement
- Feedback

FEDERAL HIGHWAY ADMINISTRATION

Asset Management

What is Asset Management ?

Key Elements

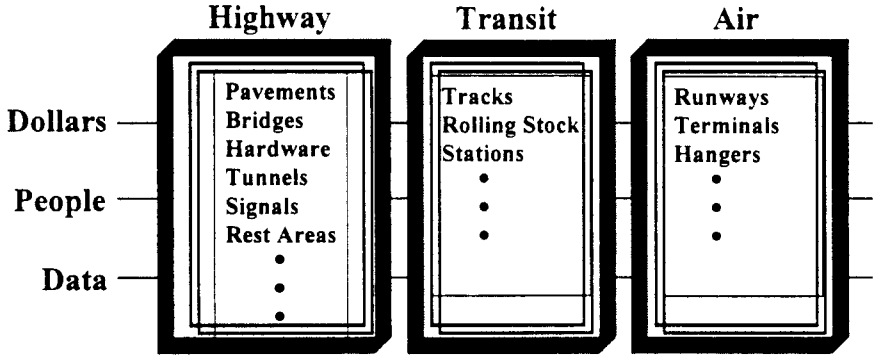


FEDERAL HIGHWAY ADMINISTRATION

Asset Management

What is Asset Management?

Broad Range of Assets



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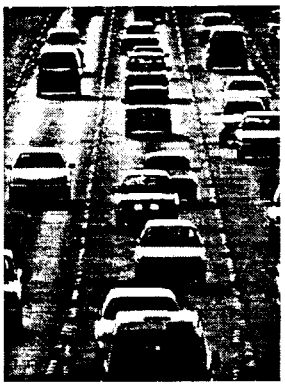
Asset Management

Why Asset Management
Driving Trends

Transportation Environment

- System Demands
- Personnel Constraints
- Increased Budget Demands



FEDERAL HIGHWAY ADMINISTRATION

Asset Management

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FEDERAL HIGHWAY ADMINISTRATION

Asset Management

Why Asset Management
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Transportation Environment

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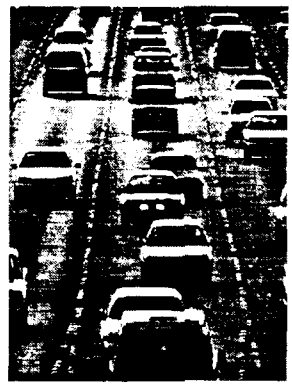


FEDERAL HIGHWAY ADMINISTRATION

Asset Management

Why Asset Management
Driving Trends

Accountability

- What is Bought with Public Funds
- How Spending Decisions are made
- What is Accomplished

FEDERAL HIGHWAY ADMINISTRATION

Asset Management

Why Asset Management

Driving Trends

GASB Statement No. 34

- New Financial Reporting Requirement for States
- Requires Recording of Long-Lived Infrastructure
- Depreciation or Preservation (Asset Management) Approach

Why Asset Management

Driving Trends

Technological Advances

- Increasingly powerful computers
- Sophisticated analytical tools and techniques
- Advances in information technology

How Do We Get There?
FHWA Office of Asset Management

- FHWA Reorganization
- Consolidate Disparate Functions
- Partnership with AASHTO

FEDERAL HIGHWAY ADMINISTRATION

Asset Management

How Do We Get There?
AASHTO/FHWA Partnership

- AASHTO Task Force
- Workshops
- AASHTO Guide to Asset Management (NCHRP)
- AASHTO Strategic/Action Plan

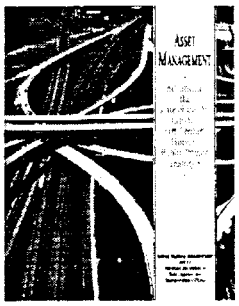
FEDERAL HIGHWAY ADMINISTRATION

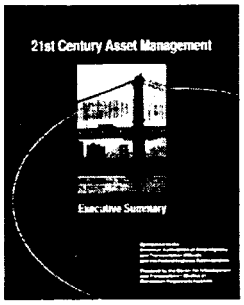
Asset Management

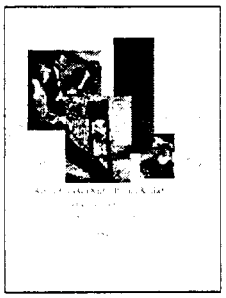
How Do We Get There?

AASHTO/FHWA Partnership

Transportation Asset Management Workshops







FEDERAL HIGHWAY ADMINISTRATION

Asset Management

How Do We Get There?

AASHTO

Strategic Plan - Goals

- Develop Partnerships
- Develop an Understanding
- Develop Tools and Research
- Inform Leadership on Use
- Assist Member States

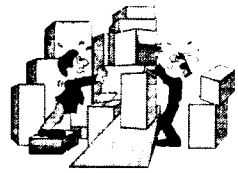
FEDERAL HIGHWAY ADMINISTRATION

Asset Management

Conclusion

Keys to Success

- Sustained Political Commitment
- Executive Leadership
- Commit Resources - State and National Level
- Facilitate Sharing between States
- Pool Organizational Resources - AASHTO, TRB/NCHRP and FHWA



FEDERAL HIGHWAY ADMINISTRATION

Asset Management

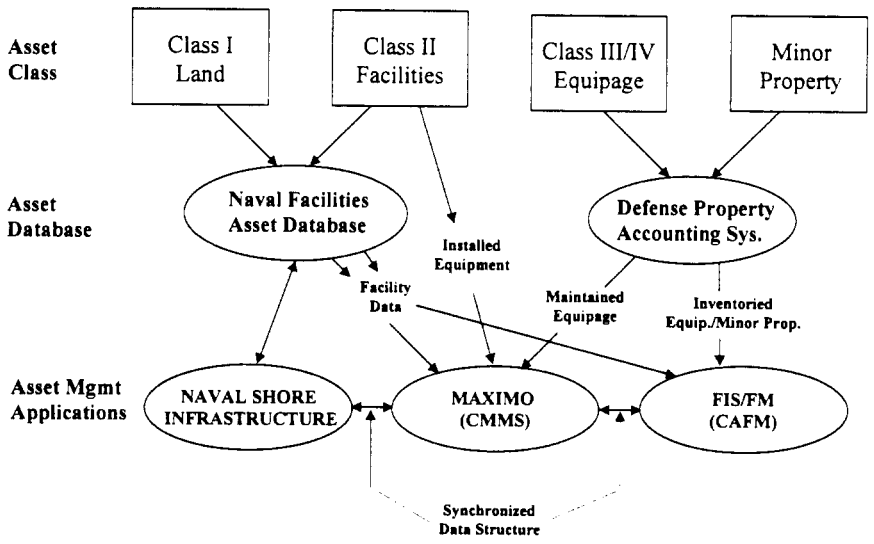
APPENDIX E

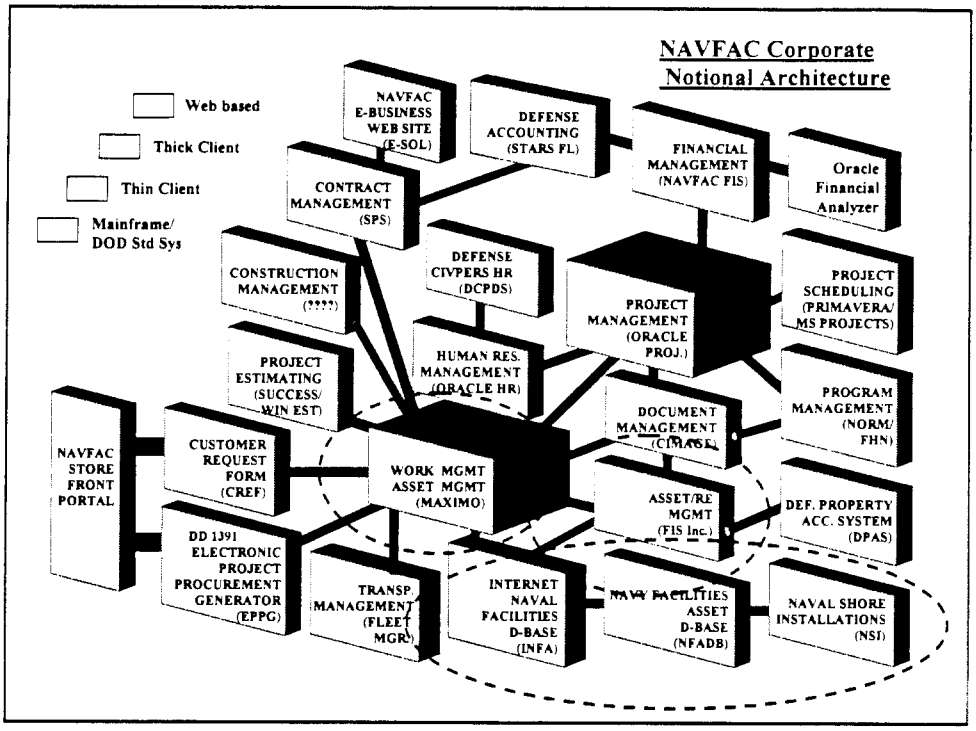
CAPTAIN DENNIS FLOCKMEYER, CHIEF INFORMATION OFFICE, NAVFAC

Total Facility Asset Visibility Ashore

D. R. Plockmeyer
CAPT, CEC, USN
NAVFAC CIO/CTO

Facility Asset Management




NAVFAC Corporate
Notional Architecture
Web based
Thick Client
Thin Client
Mainframe/
DOD Std Sys
NAVFAC
E-BUSINESS
WEB SITE
(E-SOL)
DEFENSE
ACCOUNTING
(STARS FL)
FINANCIAL
MANAGEMENT
(NAVFAC FIS)
Oracle
Financial
Analyzer
CONTRACT
MANAGEMENT
(SPS)
CONSTRUCTION
MANAGEMENT
(????)
DEFENSE
CIVPERS HR
(DCPDS)
PROJECT
MANAGEMENT
(ORACLE
PROJ.)
PROJECT
SCHEDULING
(PRIMAVERA/
MS PROJECTS)
PROJECT
ESTIMATING
(SUCCESS/
WIN EST)
HUMAN RES.
MANAGEMENT
(ORACLE HR)
DOCUMENT
MANAGEMENT
(CIMAGE)
PROGRAM
MANAGEMENT
(NORM/
FHN)
NAVFAC
STORE
FRONT
PORTAL
CUSTOMER
REQUEST
FORM
(CREF)
WORK MGMT
ASSET MGMT
(MAXIMO)
ASSET/RE
MGMT
(FIS Inc.)
DEF. PROPERTY
ACC. SYSTEM
(DPAS)
DD 1391
ELECTRONIC
PROJECT
PROCUREMENT
GENERATOR
(EPPG)
TRANSP.
MANAGEMENT
(FLEET
MGR)
INTERNET
NAVAL
FACILITIES
D-BASE
(INFA)
NAVY FACILITIES
ASSET
D-BASE
(NFADB)
NAVAL SHORE
INSTALLATIONS
(NSI)